

III. *Part of a Letter from Mr Anthony van Lewenhoeck, F. R. S. containing his Observations on some Animalcula in Water, the dissolution of Silver, &c.*

Delft in Holland, Feb. 5. 1703.

ABout the latter end of *July*, standing on the Bank of the *Canal* that is before my House, and observing the Water, which gently flows thro' our Town, and which is very clear, and almost of the colour of the *Maeſe* Water, I saw something shining in it, and being desirous to know what it was, I took a Glass Tube of almost a Foot length, and of a Fingers breadth, and tying a String about it I let it down into the Water perpendicularly till it was quite full.

Looking upon this Water with a Microscope, I observed several sorts of Animalcula Swimming therein, some of which I don't remember I had ever met with before.

I view'd this Water several times in one day, but could not find out the shining Matter which I had seen in the Canal.

On the 4th of *August* I made my observations again, and then I could see in 8 or 10 places several small Particles sticking so fast to the sides of the Tube, that altho I put the said Water into a gentle motion, I could not remove them.

This induced me to view the same with my Microscope, and then I could plainly see those Particles, representing a large Bough or Branch of a Tree, with a great number of Sprigs about it.

Most of these Branches were fastned with their Stems to the sides of the Tube, and seem'd to arise out of a very small Particle of Matter that was likewise so fastned.

That

That I might be farther satisfied herein, I took an other Tube that was longer and broader than the first, and fill'd it with the same Water, having first rinsed it once or twice.

I viewed this Water also several times, after it had stood 30 hours in the Tube, and again discovered the same sort of Boughs as compleat and perfect as if you were to see the same with your naked eye on a Tree, and amongst others one in such a position, as if the thick Branches from whence the rest proceeded, lay just against my Eye.

Before this last Particle I placed a Microscope, with a design to observe from time to time whether it would encrease in bigness.

After the space of six hours I could not find that it was grown any bigger, and I observed that the ends of the Twigs, which were about twenty, were laden with little transparent Bubbles, whose Diameters were thrice as big as the extreme parts of those Twigs.

Now having likewise observed about the said Twigs a sort of Transparent Animalcula of the same size with those Bubbles, I did suppose that the before-mentioned round Bubbles were the same with those Animalcula that had taken their station on the ends of the Twigs; and I was confirm'd in that opinion when I perceiv'd the next day in the morning, after that the Water had been 48 hours in the Glass Tube, that most of these round Bubbles were off the Twigs, and that a very few of the Animalcula were got upon the Twigs, and remain'd there immovable, whilst I made my observations.

Twelve hours after this I could not see that the foresaid Branches were grown larger; but I then observed that several of the small Twigs were again invested with round Bubbles, and an Animalculum that was about fifty times as big as one of the Bubbles, was running on one of the Branches; and forasmuch as the end of one of the Twigs, where that Animalculum had been, was again laden with the said Bubbles, I concluded, tho I had no ocular proof of it, that

the said Animalculum had dropt her young ones there.

On the 6th of *August* I took another Glafs Tube of above a foot long and an inch in diameter, one end of which was hermetically seal'd, that there might be no cause of fufpicion that thefe branches or twigs proceeded from the Cork; and having rinsed the fame two or three times, I fet it on my Desk, and viewed it feveral times, but could perceive no Branches till after the Water had flood above 40 hours in the Tube; after which I took a Microscope and fastn'd it to the Tube, to fee whether the Branches grew any bigger after the first difcovery of them, but as nicely as I viewed them I could perceive no alteration.

Now I could fee on the extream parts of the said Twigs 3 or 4, or fometimes 5 round Bubbles like Rofes by one another, which was a very agreeable fpectacle, for when one of thefe Branches (which was only fastn'd to the Glafs by its thickeft end) came to be removed by that fmall motion into which I put the Water, all the five fmall Twigs were likewise put into motion, and the fame motion was likewise imparted to the Bubbles, tho some of their Stalks were fo exceeding fmall that I could not fee how they were joyn'd to the said Twigs.

I pour'd out the Water very gently from the Glafs Tube, with intention that the Branches which were fastn'd by their Stems only to the fides of the Glafs (whilst their Twigs were kept in a continual motion by the Water) might lye along on the Glafs, to the end that my Limner might draw them the better.

Fig. 1. A B C D E F Represents the said Particle as it lies on the fide of the Tube.

A. Shews you the Stem or Root of the said Branch, and whereby it was joyned to the fides of the Glafs.

Here you may fee what a vast number of Branches and Twigs there are in this fingle Figure, which indeed appears irregular upon the Paper; whereas in the Water where they were unravell'd and could play free, it was a very agreeable fight,

light, being in colour like Oak, and in several places beset with round Bubbles, just as if they were compos'd of such Particles.

G and D represent some of these Particles of the Figure of a Rose, which seem to consist of round Bubbles, as also H. tho the Stalks of them are so fine that I could not perceive them to be united to the main Branch, however when that mov'd they mov'd also.

As soon as the Water was pour'd out of the Glass Tube I immediately viewed the said Branch, and between two of the Sprigs B D and B E, I saw two of the small Animalcula swimming in the little Water which remained unexhaled amongst the Twigs, and their Figure was like the Bubbles that were described by H. During these my observations I discovered an exceeding small Particle breaking off from one of the Particles or Bubbles under the said letter H. and presently swum off with a small motion, but the whole space of its progress was not above a hairs breadth; the said small Particle was certainly an Animalculum, for I could plainly see it turn and wind it self about; I observed a little motion also in another of these Particles or Bubbles, that I have said before were like a Rose, but that Particle remain'd still entire.

On the sides of the same Tube lay several other small Branches, but they were not so perfect as the first Figure, and when the Water was pour'd out, they appear'd like Fig. 2. I K L and Fig 3. M N O.

What shall we say concerning these Boughs or little Trees? We can't imagine that they proceed from a Seminal Matter in the Water, but rather with submission to better Judgments, that they are compos'd of that Matter which ranging in small Particles thro the Water, does by a kind of natural inclination cement or coagulate into one body; and this will not seem strange to any one who has seen the like experiment in the filing of Iron, for if you apply that part of the Iron that is filed and remains still warm to the Filings, it will im-
medi-

mediately attack the said Fileings, and they shall hang down like a Chain from the Iron ; nay, if you apply these Fileings to a Magnet, the Attraction will be much stronger:

Now I am speaking of Inclinations, I can't forbear acquainting you, that I have several times for my diversion dissolved Silver in *Aqua fortis*, and as soon as I put the Silver into the Menstruum have endeavour'd to observe the operations. and have always found a great number of Air-bubbles arising from the Silver, which before they were separated from the Metal were as large as a common pins head, or as a grain of Sand.

These Air-bubbles, as soon as they left the Silver, and in proportion to their mounting toward the superficies of the Water, grew less and less, insomuch that they did almost escape ones sight, and presently after vanish entirely, and this change happen'd usually in the space of three Pulses : Some of these Air bubbles lasted a little longer, others again, tho as big as a Pins head, burst in pieces before my eyes, without leaving other and smaller Bubbles (part of themselves) behind them.

For my farther satisfaction in this matter, I prepar'd a Glass Bottle, whose Axis was an inch and half large, of the shape as is delineated by Fig. 4. a, A B C D E F G, whereof A B C D represents the great Bowl or Globe, and A D E G the less, and F. the Bore or Orifice of the Glass.

This Glass I placed sloping as in the Figure, after that I had first fill'd it a little above E G with *Aqua fortis* whilst it stood perpendicularly ; and then I put into it two grains of fine Silver which lay at the bottom of the Glass, in such proportion as is express'd in the said Figure at B. whereby all the Bubbles proceeding from the Silver must ascend perpendicularly to C ; with this perswasion, that when the quantity of Air that was extracted from the Silver should arrive at C. it would remain there, and that in proportion to the space that the said Bubbles should possess there, so much of the *Aqua fortis* would be protruded from the greater Bowl to the less.

Now

Now when I saw that but very few more Bubbles arose from the Silver, I could perceive very plainly that most of those Air-bubbles that had been extracted, did not only grow less before they arrived at C, but were quite vanisht.

Now that the Silver was visibly united to the *Aqua fortis*, and had remain'd so 24 hours, there was as much Air in the Glass at C. as would fill the space of 3 or 4 Pins heads; whereas there arose such a vast number of Air-bubbles from the Silver during its dissolution, that I was amaz'd what was become of them, seeing they were in a manner vanisht, without leaving any Traces behind them.

I caus'd the Air in C. to dislodge out of the Orifice F. by raising the Glass perpendicularly, and then I threw in three times as much Silver, whereupon an unspeakable number of Air-bubbles continually ascended towards C. but were dispatch'd before they could arrive at the top, and such of them as were bigger, and held out till they came to C. did then burst in pieces, without leaving any marks behind them, except always as much Air as would fill the space of three or four Pins heads.

Furthermore, I put 30 grains of Silver into the said Water, without observing any more remarkable difference, save that there remain'd at C. as much Air in bigness as an ordinary Pea.

In these my observations I have likewise taken notice, that the larger the Air-bubbles are, which arise from the Silver, the faster they mount towards the top of the Glass; and this has place also I imagine in that air which the Learned call *Aer Subtilis*, viz. how much the larger the Particles of Air be that perspire from our bodies, the faster they ascend; and so likewise in the descent of all heavy bodies towards the Earth; as for instance, take two Iron Balls, one of an Inch in diameter, and the other of 5 Inches, and let these two Iron Balls fall at once from a certain equal height, my position is, that that Ball whose Axis is 5 Inches, must cut thro a Column of Air 25 times greater than the Column

of Air thro which the one Inch Ball paffes ; this being granted, I fay then, that as thofe two Columns of Air thro which the Iron Ball muft pafs, are as 1 to 25, fo the Gravitation of the faid two Balls are as 1 to 125.

Now that Ball which being 125 times heavier, and paffes thro a Column of Air that is but 25 times bigger than the other, muft needs, I fay, 'move quicker in its defcent than the leffer Ball, fo confequently muft thofe Particles (fupposing them to be compos'd of the fame Matter) that are biggeft, firft and foonest perfpire thro our Bodies.

But to return from this digreffion, having firft weaken'd fome of this *Aqua fortis* thus impregnated with Silver, I put a little of it in a clean Glafs Tube, and now and then threw into it a little Copper of the bignefs of a grain of Sand, and then viewing my Silver water with a Microfcope, I obferved with a great deal of pleafure, how the Silver in this clear Water was coagulated into fuch bodies as are defcribed by the above-mentioned Trees ; which Coagulation we may call an Inclination ; and that I may give you a better Idea of this kind of Coagulation, I caus'd the Painter to defcribe a fmall Particle of the Silver no bigger than a large Sand, *vid.* Fig. 4. P. Q. R. S. T.

I was amaz'd to fee in a few feconds of a Minute, fuch Coagulation of branched Particles (which even thro a good Microfcope were invifible) arifing from a feeming clear Diaphanous and Liquid Matter.

Now what fhould occafion fuch a Coagulation, infomuch that no Silver fhall remain in the Water, is to me wholly in-ferutable.

From thefe Coagulated fmall Silver Particles, my thoughts made an excurfion to the rich Silver Stone which comes to us in fmall fragments from the *West Indies*, and which the Virtuoso's keep as Rarities in their Cabinets, of which alfo I have a little.

Now if we ferioufly confider the Silver in that Stone, we fhall alfo find that its Particles are coagulated in juft fuch branches

branches as appear'd in the abovesaid Water by the help of my Microscope, from whence I am the more fully confirm'd in my hypothesis, that when the parts of that Stone were a fluid substance, the Silver Particles were also mingl'd with them, and when the Stone came to consolidate, the Silver also was coagulated in Branches just as we see it now lying in the Stone, wherewith it is surrounded, and as it were imprison'd; from whence several have conceited that in process of time the Silver grew in the said Stone.

In the *Philosophical Transactions* No 243. p. 293. I observe that Sir Robert Southwell, a Member of the *Royal Society*, had acquainted that Body, that he had seen a Gold Ducat beaten very thin, and then dissolv'd in two Ounces of *Aqua Regia*, into which was steeped a Linnen Rag and then dried, and then steeped again, and as often dried, till it had suckt up all the said Water; after which they burnt the Cloath to Tinder, and so gilded the Silver, by rubbing it with the Ashes or remaining matter of the said Linnen.

I took a piece of Gold and threw it into a proportionable quantity of *Aqua Regia*, in the dissolving of which I saw Air-bubbles ascending in like manner as I said before of the Silver.

After a little time I took some of the *Aqua Regia* thus impregnated, and laid it on a clean Glass, to observe, after the mingl'd Salts were coagulated, what Gold Particles I could discover therein.

When it was fair warm weather the Salts were for the most part coagulated, but in so many several sorts of Figures that they were hardly to be accounted for, sometimes they represented an exact Hexangular Figure, by and by the very same Figures were no less irregular; the occasion of which was, as I conceive, because the Coalescence of new Particles was not equal on every side; but that which was the most remarkable was, that upon these Salt Particles, that were as transparent as yellow Crystal, there lay other Salt Particles of a fine Gold colour, and sometimes they appear'd

to me as if these fine Gold colour Salts were shut up in the other salt Particles, which caus'd a very agreeable Phenomenon ; but when the weather grew damp and moist, all the Cryстал Salts were melted, and the Gold-colour Salts were mixt with the common Particles.

I took another little piece of Gold that had been workt by a Goldsmith, and having beaten it very thin, I put it into the same Glafs where my other Gold had been, with *Aqua Regia*, and observ'd that a white Substance was separated from it and subsided in the bottom of the Glafs ; for we know that as *Aqua Fortis* dissolves Silver, whilst the Gold escapes untoucht, so *Aqua Regia* dissolves Gold, without affecting the Silver at all.

Hence I infer, that that Gold was alloy'd with some Silver, which was the White Substance, separated, as I said before, whereas according to our Laws the Wrought-Gold should consist of 22 Carats.

The Piece of Gold that lay in the *Aqua Regia* would not be united with it ; whence I concluded that there was too much Gold and too little Water, for I had made the Glafs so hot that I could not bear it with my hand.

Moreover, I took a small piece of Copper and put it into *Aqua Regia*, where a little Gold had been already dissolved, and presently observed that the *Aqua Regia* began to operate upon the Copper, as if it had lain in *Aqua Fortis* ; the Gold also cemented with the Copper, but in much smaller Branches than Silver in *Aqua Fortis* ; and I saw that the Gold coagulated so strongly with the Copper, that the Water about the said Copper was quite divested of its Gold colour ; and after an hours time the Water was so impregnated with the Particles of the Copper that it assumed a Green colour, and then one might perceive with the naked Eye the Gold that lay about the Copper.

Again, I took other *Aqua Regia*, that was impregnated with so much Gold that it could dissolve no more, and observed that the coagulated Salt-particles were of an extraordinary

traordinary fine Gold colour, and very agreeable to the sight, being composed of exceeding small Particles, and the Corners or Angles very regular.

I placed these Salts before my Microscope, that I might impart to others also the diverting spectacle, and all that saw it own'd they had never in their lives seen so fine Gold ; and it seem'd of such a Figure and Texture as if it had been a Piece of Gold newly taken out of the Mines.

Now, in order to expose to view the Coagulated Salt Particles in their first Coalition, I put the said Water impregnated on a clean Glass, and then caus'd part of it to run off the Glass again, that the remainder might lye as thin as possibly in the Glass without touching it, imagining that the said Water lying thus thin, the Salt Particles might Coagulate the more regularly ; and I observed afterwards that most of those Salt Particles were hexangular, tho so exceeding small that they did almost escape the sight, and many of them were regular Hexangles. See Fig. 5. A B C Fig. 6. D E F Fig. 7. G H I Fig. 8. K L M and Fig. 9. N O P.

Most of these Figures were as transparent as Glass, and all of them were surrounded with a Liquid Matter that was something upon the Gold colour, the which Matter did not exhale, tho the weather was very warm and dry.

Moreover, I saw an unspeakable number of Particles so exceeding small that their Figure was not distinguishable, tho I did believe them to be Salt Particles likewise ; the rather, because I could not observe any of these small Salts lying near the aforesaid great ones, which thro the sympathetic Inclination of homogeneous Bodies, I did conclude to be compos'd of a Congeries of small ones.

I saw also other Particles that were not at all Pellucid, which I suppose were surrounded with so many Gold Particles, that they were not only of an irregular Figure, but also opaque.

Many of these Salt Figures were more protuberant in the

Circumference than in the middle, and had also several Rings or Circumferences, which does still the more confirm me in the opinion of those secret Inclinations of like Bodies, and thus in their increase they preserve the same Figure which the single Salts had put on at their first Coagulation.

Into such Water I also put a little piece of Copper, and observ'd that immediately the Gold had partly united itself to the Copper, but the *Aqua Regia* had not so much power over the Copper as to protrude out of its substance so many Air-bubbles, as it might otherwise have done if there had not been so much Gold therein; the said Water had thereupon assum'd a greenish colour, and all the yellow colour was turn'd into Coagulated Gold, insomuch that one might with the naked eye distinguish the Gold from the Copper, particularly the extream parts of the little Boughs which were made by the Coagulated Gold, altho the said Coagulated Gold consisted of Particles that were so very small and minute, that they did not appear larger with the help of a good Microscope than the smallest grains of Sand to the naked Eye.

When I weaken'd with Rain Water the *Aqua Regia* which had been impregnated with a great deal of Gold, and then put into it a bit of Copper, I observ'd that the Gold in a short time was coagulated or united with the Copper, and that the Water was turn'd to a light green:

I have also observ'd that the small Twigs of these Coagulated Particles were not of a fine Gold colour, from whence I inferr'd that there was Copper blended together in them.

The said *Aqua Regia* which had been impregnated with Gold, having remain'd some days in the Glass, I perceiv'd that where it was thickest, it was covered with a Film or Skin, and that most of the Salts when the Weather was not warm, nor the Sun shin'd, were dissolv'd, and much more in Rainy Weather.

Moreover, I expos'd the Glass with the said Water to such

a heat of the Fire that the Salts evaporated in Smoak, and that part of the Glass where there lay least of the *Aqua Regia*, assumed a colour that was something upon the red, but where the said Water lay thicker together, we could not see the fine shining Gold with the naked Eye, but when we rais'd that Glass, where the Gold lay higher to the light than the Microscope, I saw that the Gold Particles were not united with the other, but now and then Coagulated into Branches, and where the Gold Particles were not thus Coagulated they were so very small, that how nicely soever I viewed them they escaped my sight; and tho there lay together more than a thousand Millions of these small Particles, all of them did not make a body that was bigger than one single grain of a large Sand.

Where this Matter lay thin and dispers'd, I observed that the small Particles thereof were such solid and compact bodies, that did not admit of the least Rays of Light; and where they lay single I saw other Particles yet smaller, whose Bodies were more loose, but I imagined these last to be some Particles of that Matter, which the *Aqua Regia* had left behind it.

Now after that the said *Aqua Regia* had remain'd on some of the Glasses several days, and the Salt Particles for the most part were changed into a fluid Substance, I observed among several of the Coagulated Branches small distinct Particles, which I fancy to be Gold, tho I could not for the smallness perceive the colour of them.

To satisfy my self herein, I took a small Glass Bubble, with as much *Aqua Regia* impregnated with Gold, as was equal to something more than a great Pins head, and set it over such a strong Fire, that both the Glass and Gold were upon the melting, then viewing the Glass I saw very plainly that a small portion of the said Gold was Coagulated into Branches, and that these Coagulated Particles were round knobs or bubbles.

These Gold Bubbles were dispers'd in great numbers over the

the whole Glafs, in some places close together, in others thinner, of different magnitudes, and many of them so small, that altho I view'd them thro a good Microscope they did in a manner escape my sight ; in so much that it is almost impossible for a man to conceive, unless he has had ocular proof and demonstration thereof, that such vast numbers of Gold Globules could proceed from so small a quantity of Matter, and who knows how many more Gold Particles must coalesce in melting, to compose one of these smallest Globules.

Now tho the small Gold Particles could not be discover'd when they were surrounded with *Aqua Regia*, we could easily see the shining Gold colour of them all, now (saving only the very smallest Globules) which was no unpleasant sight, for they all appeared like so many compleat round Pellets.

In my former Letter I affirm'd that that green stuff is found upon still Waters (which we also call *Duck weed*) did not spring from the Ground, but from Seed within it.

But now in Winter, when those Ditches, in which I had seen much of this green Weed, were covered with Ice, I saw but a very little of it, and what I saw was very small of Leaf.

Having consider'd this, I thought it might be possible in warm weather for those green Weeds to spring from the Earth, tho it did not seed upon the Ground, nor encrease in bigness there.

For supposing as it really happens, that these Weeds in warm Weather by the rarefaction of those Particles of Air in their Vessels are driven up to the superficies of the Water, the same Weeds by the contraction of the Air in cold Weather will grow heavier than the Water, and consequently sink to the bottom, and according to the change of the Weather, will have their vicissitudes of emerging or subsiding.

This

This rising and falling of the green Weeds may seem strange to some people, but if they will be convinced by the Experiments of natural Philosophers whom I have followed several years, let them take a small Glass-bubble, such as is describ'd by Fig 10. Q R S T, leaving the small orifice at T open for the Water to run in and out, and let this Bubble be put into a Vessel with Water, they will find in Summer that by the dilation of the Particles of Air within the said Bubble, it will rise to the superficies of the Water, whereas the same Air, thro its elasticity, being contracted in cold Weather, will make room for the admission of a Mass of Water so much heavier than itself into the said Bubble, and then it will subside; and this will happen *toties quoties*.

IV. *A Letter from the Reverend Mr William Derham, F. R. S. to Mr John Haughton, F. R. S. containing his Observations on the Weather, &c. for some years last past.*

Upwinster, April the 5th, 1703.

I Lately sent my Weather and Tables of last year to Dr Sloane, and promis'd when I should hear from Mr Towneley in Lancashire, an Account of what he wrote that was curious: I have lately receiv'd Mr Towneley's Letter, and take the occasion of that Letter to write now to you, to give you my hearty thanks for all favours that I have receiv'd from you; as well as to send you some of that ingenious, curious Gentleman's Observations of last year, and my own.

And first, As to the most remarkable Weather, especially Rain, of last year, and the effects thereof: Mr Towneley tells me, that it is a general complaint in the North of England,

